Transportation Fuel Cell Power Systems Program

Developing clean and efficient technologies for vehicles

U.S. DEPARTMENT OF ENERGY

OFFICE OF TRANSPORTATION TECHNOLOGIES

Transportation

FOR THE 21ST CENTURY

A fuel cell produces electricity directly from the electrochemical reaction of hydrogen (from a hydrogen containing fuel) and oxygen from the air. Depending upon the fuel feedstock, fuel cells are a zero or near-zero emission technology emitting only water and trace amounts of air pollutants. Because of their high efficiency, fuel cells produce less carbon dioxide – a major greenhouse gas – than most other energy conversion systems for vehicular applications. The most promising fuel cell technology for vehicular applications is the polymer electrolyte membrane (PEM) fuel cell. PEM fuel cells are very appealing due to their high power density.

Significant progress has been made in the development of PEM fuel cells over the past seven years in virtually all areas including fuel processing, stack subsystem components, and overall systems integration. However, key technical challenges still remain for PEM fuel cells to be viable for transportation applications. Significant cost reductions must be achieved before fuel cells will be competitive with internal combustion engines, and the size and weight of fuel cell systems must be reduced to accommodate vehicle packaging requirements. Advances in both off-board and on-board fuel processing are necessary, as well as on-board hydrogen storage technologies. Precious metal requirements must be reduced and low cost, high volume processes for manufacturing fuel cell components are needed. Compact and rugged ancillary devices such as humidifiers, heat exchangers, and sensors are also needed.

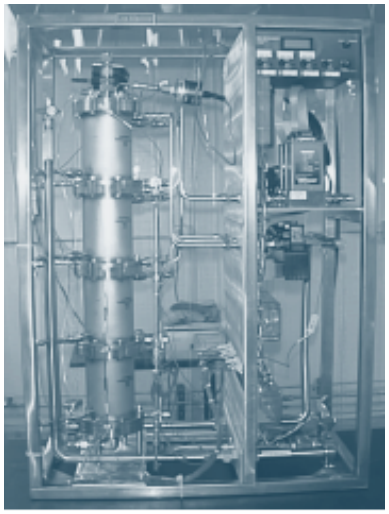
DOE Transportation Fuel Cell Power Systems Program

The Department of Energy (DOE) is leading an ambitious, cost-shared, government-industry R&D program to develop automotive fuel cell power system technologies. These technologies are expected to be highly efficient with low or zero emissions, cost-competitive, and to operate on conventional and alternative fuels. The DOE is supporting a broad range of R&D projects for PEM fuel cell technology focusing on materials, components and enabling technologies for fuel processing and for fuel cell stack subsystems as well as fuels for fuel cells. Cost reduction is a primary focus.

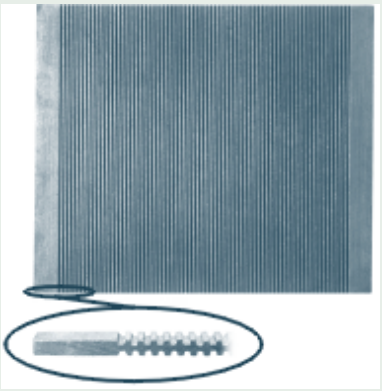
Fuels for PEM Fuel Cells

A dual pathway R&D program is being pursued to evaluate and develop fuels for fuel cell vehicles. These two pathways simultaneously address both near-term and long-term objectives. The focus of the near-term R&D pathway is evaluation of gasoline, in particular Tier 2 gasoline, as a suitable fuel for fuel cell power systems. Other fuels such as reformulated diesel, methanol, ethanol, and natural gas derived fuels such as Fischer-Tropsch liquids will also be evaluated as neat fuels for the fuel-flexible fuel processor. If Tier 2 or similar gasoline type fuel is determined to be a suitable candidate fuel, the existing refueling infrastructure will enable a widespread introduction of fuel cell powered vehicles over the next several decades.

The long-term R&D pathway will focus on developing and demonstrating the technologies needed for using hydrogen directly as a fuel, i.e. hydrogen refueling of vehicles. Initially, the R&D will focus on generating hydrogen from natural gas. This R&D thrust will parallel ongoing efforts in other DOE programs to develop technologies for producing hydrogen from renewable sources. The commercial infrastructure required to deliver hydrogen for vehicle refueling does not exist today. A low cost, small scale, natural gas, steam reforming system with related refueling systems at existing gasoline stations holds the most promise for safe, economical hydrogen use in highway vehicles. The development of natural gas reforming and refueling technologies at existing service stations would provide a distributed fuel infrastructure and thus facilitate the introduction and use of fuels derived from renewable sources. Thus, when renewable feedstocks and related



$50kW_e$ catalyzed preferential oxidation (PROX) carbon monoxide cleanup system (Los Alamos National Laboratory)



Flow field of a compression molded, carbon composite bipolar separator plate (Gas Technology Institute)

hydrogen technologies become commercially viable as transportation fuels, a distributed hydrogen refueling infrastructure will exist. Hydrogen storage technologies will also be developed with the DOE Hydrogen Program.

Fuel Processing

In recent years, the DOE Fuel Cells for Transportation Program has increased its emphasis on fuel processing, recognizing that fuel flexibility and compatibility with the existing fuel infrastructure are key requirements. Historically, the development of fuel processing technologies has lagged behind fuel cell stack development. This is especially true for PEM fuel cells because of the challenges to purify the reformate gas. In terms of transient response and start-up capabilities, fuel processing technologies have not yet achieved performance levels acceptable for automobiles. Research is addressing critical technical barriers including start-up time, carbon monoxide (CO) cleanup and fuel processor durability, emissions, and system integration.

Stack Subsystem Components

The primary challenge for stack subsystems is to reduce the cost of components and subsequently of integrated fuel cell power systems from today's $300/kW (at high production volumes) to the program target of $45/kW. Membrane electrode assemblies (MEAs) are the core of the fuel cell stack and require very high quality and production yields to achieve automotive cost and performance targets. DOE is working with industry to develop low platinum MEAs based on nanostructured thin film catalysts and support systems. Most importantly, DOE is developing MEAs in parallel with high volume process development to meet cost targets. The Program is also developing low-cost, compression-molded, carbon composite bipolar separator plates and design concepts for mass production.

Integrated Systems

Industrial suppliers to the Program will deliver 50-kW reformate capable stack systems with supporting gas, thermal, and water management systems, as well as integrated fuel cell systems combining their stacks with fuel-flexible processors and balance-of-plant components. System testing during 2001 will measure the progress achieved toward program targets and will identify further challenges that will be used to direct future research efforts. DOE has played a major role in bringing about the demonstration of these first full-scale, fully functional fuel-flexible fuel cell systems. Future system integration and packaging activities will occur primarily within the automotive industry and their suppliers. The DOE Program will now shift its focus from integrated systems to development of materials, components, and enabling technologies for fuel cell systems to improve performance and lower cost.

Partnerships for Success

To address the challenges facing fuel cells for transportation requires a range of R&D projects with fuel cell and fuel processor developers, national laboratories, and universities. Contracts and cooperative agreements with industry and universities are implemented through competitive processes while national laboratories are directly funded based on their capabilities and performance. The DOE fuel cell R&D projects require a minimum cost-share of 20 percent from industry partners. Examples of key industrial suppliers, national laboratory, and university participants in the DOE Fuel Cells for Transportation Program include:

- 3M Company
- A.D. Little
- Acurex
- Argonne National Laboratory
- Electrochem
- Energy Partners
- Foster-Miller
- Gas Technology Institute
- W. L. Gore
- Honeywell
- Hydrogen Burner Technologies
- International Fuel Cells
- Lawrence Berkeley National Laboratory
- Lawrence Livermore National Laboratory
- Los Alamos National Laboratory
- McDermott
- Meruit
- Nuvera
- Oak Ridge National Laboratory
- Pacific Northwest National Laboratory
- Penn State University
- Plug Power
- Southwest Research Institute
- Spectracorp
- University of California, Davis
- University of Michigan
- Vairex Corporation

For more information on how DOE is helping America remain competitive in the 21st century, please contact:

JoAnn Milliken
Office of Transportation Technologies
(202) 586-2480
joann.milliken@ee.doe.gov
http://www.ott.doe.gov

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